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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Dredge Operations

Lubrication of
Attendant Machinery

PUBLISHED BY
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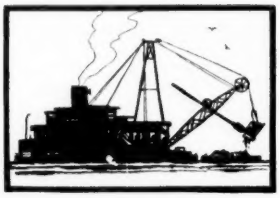

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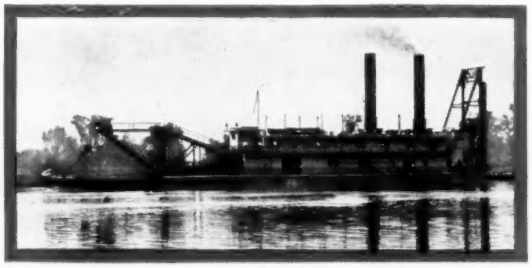

Atlantic Gulf & Pacific Company's "Pittsburgh." A steam powered turbine unit.

But just as a successful dredging operation is the result of proper equipment and experienced skill, so it is with effective lubrication. The proper selection of crudes, careful refining methods, and an engineering knowledge of the machinery for which the lubricant is recommended are essential elements in maximum operating efficiency—minimum operating cost.

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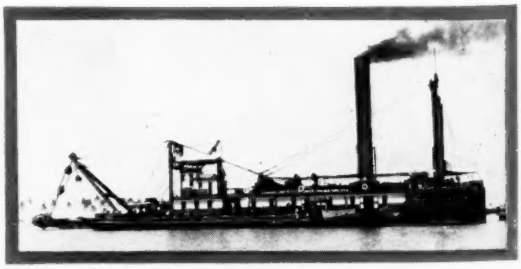

The Dredge "Peru," Gahagan Construction Corporation

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Texaco Petroleum Products

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LUBRICATION

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Dredge Operations

Lubrication of Attendant Machinery

PUBLIC Works activity has attracted the attention of the builders of many types of machinery, in the hope that it will be instrumental in improving the recovery of the heavy duty machine industry. Equipment of this nature plays an important part in the handling of materials; it involves power generating machinery, conveyors, pumps, and covers the entire field of excavating work. Dredge operations constitute an important part of this dual program of recovery and improvement of the living conditions and means of transportation along the river banks in many parts of the country. It is to be expected that more effective maintenance of waterways over definitely controlled courses will be a decided prevention of devasting floods, and an adjunct to irrigation projects which will markedly reduce the costly hardships incident to future droughts.

Builders of equipment necessary to dredge operations have anticipated the demand upon their resources, and their activities are worthy of discussion, more particularly since the dependability of such equipment is contingent upon effective lubrication, which must frequently be carried out under adverse operating conditions which may include the presence of water, abrasive sands, considerable pressure and frequently a wide range of operating temperatures.

TYPES OF DREDGES

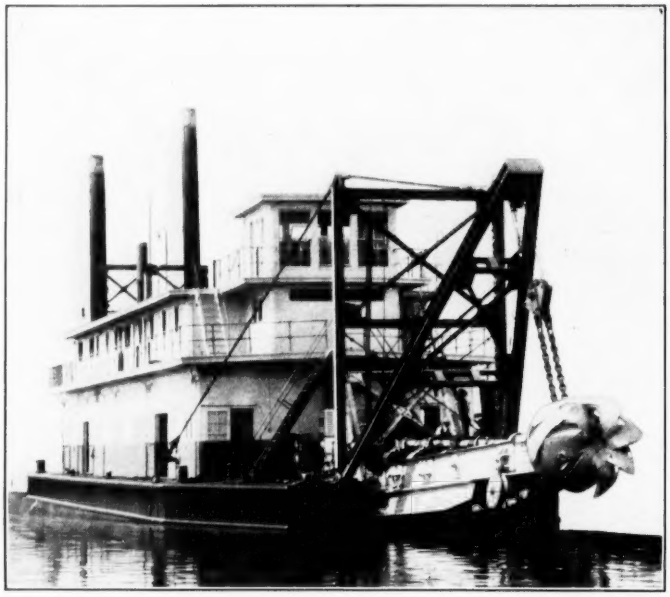
Dredges are broadly classified as "Hydraulic," "Dipper" or "Elevator" type, according to the manner in which the materials are handled.

The Hydraulic Dredge

The hydraulic dredge is a pumping type of machine employing a heavy duty large size centrifugal pump for suction of sand, mud or silt, from the channel being dredged and the transfer of same to the locality to be filled. Frequently such materials are carried through several thousand feet of large size pipe to the point of discharge. This pump is driven by the main engine, which may be a reciprocating steam or Diesel unit, or a reduction geared steam turbine. Electric motor drive has also been employed on some more recently designed dredges, using the Diesel or steam turbine as the prime mover for an electric generator. The Diesel-electric or turbo-electric dredge is regarded by some operators as affording greater flexibility in control of pump speeds and elimination of power losses. Obviously, however, it presents a wider variety of machinery which must be carefully lubricated.

Hydraulic dredging requires the use of a cutting element for disintegration of the material to be pumped, prior to suction. In the design of such dredges the cutter is operated independently from the main centrifugal pump,

by an auxiliary engine which may or may not be geared, according to its operating speed. Where reciprocating steam power is used, it is customary to locate the engine on the ladder. On the turbine or Diesel driven dredge, however, the cutter engine or electric motor is normally installed in the main engine room.



Courtesy of Ellicott Machine Corporation

Fig. 1—General view of the Diesel-electric hydraulic dredge "Orion". The main pump is direct connected to and driven by a six-cylinder, 940 h.p. Busch-Sulzer two-cycle engine operating at 300 r.p.m. full load speed. Auxiliaries are electric driven by a 450 h.p. engine of similar type direct connected to a 300 k.w. generator.

The cutting engine operates simultaneously with the main pumping engine in order to assure maximum cutting of mud or clay and to reduce the possibility of clogging or overloading the pump. In fine sand dredging it may not always be necessary to use the cutter.

The position of both the cutter and the pump intake can be raised or lowered, or swung through a fairly wide arc by means of an adjusting ladder which is supported by an A-frame extending from the bow of the dredge. Control of the depth of pumping is accomplished by steel cable connections through the ladder to the steam or motor driven hoisting drums in the engine room. The range of swing in average service will cover an arc of from 200 to 300 feet.

The forward end of the dredge is swung back and forth across the cut by swinging ropes attached to anchors. Forward movement is accomplished both by taking up on the anchor cables as well as by use of two spuds, or large-diameter vertical steel cylinders located at the stern. These can be raised and lowered independently by steel cable connections via the same hoisting machinery which controls the anchors and ladder. By alternately raising and lowering each spud, and taking up on the opposite anchor cable at the same time the dredge can be walked ahead in zig-zag fashion, much like a boy walking on stilts.

The Dipper Dredge

Units of this type operate in very much the same manner as the power shovel, using a scoop for handling of the material. In contrast with the hydraulic dredge, this process of handling is intermittent. On the other hand, it is practicable to handle larger and more awkwardly shaped materials than would normally pass through a centrifugal pump, and which might deflect the cutter.

The equipment essential to a dipper dredge will involve a main engine or engines of the reciprocating steam or Diesel type, or a turbo-electric installation. Lubrication of these elements will be alike in either the dipper or hydraulic dredge. The former, however, will present a more acute problem of wire rope lubrication, by reason of the more severe duty and the heavier loads which must be handled. Protection of wire rope must therefore be given very careful consideration.

The Elevator or Bucket Type

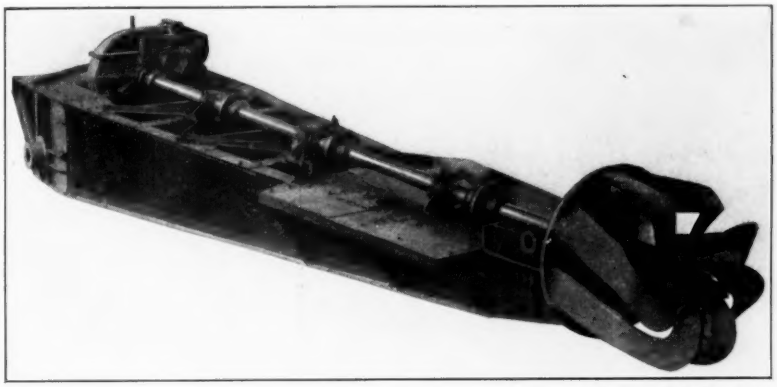
Elevator dredges have proved especially adaptable to mining operations, although they are also suited to waterways service. Dredges of this type handle materials by means of a close connected, water-tight bucket chain. The operation of this type of dredge in mining service will be particularly interesting to those whose normal understanding of dredging is restricted to comparatively deep water handling of materials. In placer mining the buckets of the elevator carry the material inboard to a revolving screen which rejects the coarse particles of no value, and directs the fine gold or platinum bearing material to a suitable sluice box and table for final separation. The waste or tailings from the sluice box are normally carried overboard at the stern of the dredge.

This type of dredge has proved its value to mining service by reason of the steady action of the bucket line which enables removal of materials with minimum agitation, thereby preventing settlement of heavy metals to the bottom, from which reclamation might be difficult. The capacity of the buckets is from four to twenty cubic feet, and they will normally dump at a rate of 18 to 30 per minute,

according to the size of the gravel and depth of digging.

DIESEL ENGINE REQUIREMENTS

The basic principles of Diesel engine lubrication will be of considerable interest to many dredge operators who may be confronted with the possibility of alterations in engine room equipment. In particular, they should understand those factors which may affect lubricating oil consumption, from the viewpoint of possible contamination, exposure to abnormally high operating temperatures, loss through leakage or aeration, and the effects of pressure.



Courtesy of Bucyrus-Erie Company

Fig. 2—Digging ladder of an hydraulic dredge. Note location of steady bearings and reduction gear.

The all important point to many Diesel operators is when to change oil. This is a difficult question to answer. Broadly speaking, it will be advisable when contamination in the circulating system has progressed to such a degree as to render the oil incapable of developing and maintaining a dependable lubricating film. Those substances which would tend to contaminate such an oil include water, fuel oil, dust and dirt, silica, iron oxides and carbon residue.

Formation of both sludge and iron oxides will frequently be influenced by water. In turn, these contaminants will tend to promote formation of permanent emulsions which would lead to the development of insoluble sludge. While this latter might not always be abrasive, it would tend to accumulate in oil grooves and distributing piping, to reduce flow of oil to the bearings. Obviously, any contamination as mentioned above would affect only crankcase oils or oils which are passed through the engine by an external circulating system, and subject to re-usage.

Where the mechanical force feed lubricator is employed for cylinder lubrication, the oil is used only once. In trunk type engines, where the base of the cylinders is open to the crankcase, any increase in temperature at this point might require increase in the rate of oil feed to the cylinders, to assure the maintenance of a suitable film.

In engines of the splash lubricated type, agitation and aeration, according to the prevailing temperature, must be carefully considered. In the crankcase, aeration might lead to considerable loss of oil, with the formation of objectionable oily accumulations on the outside of the engine. Reduction in the oil level will often overcome this fault and reduce agitation and aeration. It is, of course, more easy to control lubrication in the crosshead type engine where oil is pressure circulated. In an engine of this type, crankcase temperatures will often be lower and the possibility of loss of crankcase oils through blow-by past the piston will be eliminated.

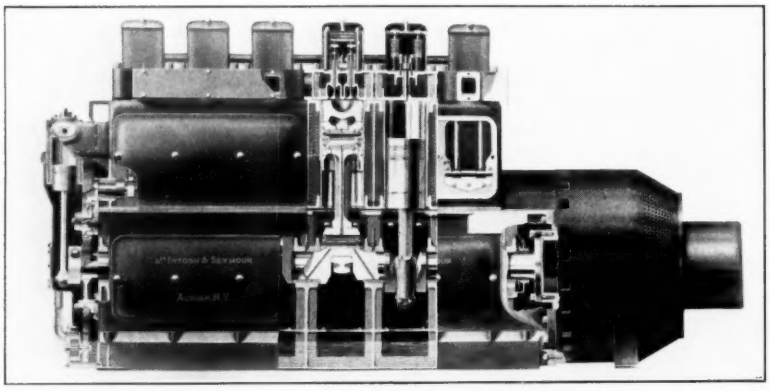
Lubricating oil economy and durability will be affected by constructional and operating conditions, for service in a four-cycle engine is quite different from that in a two-cycle. Whether or not an engine is of the trunk or crosshead type is also an influencing factor. In other words, crankcase oil in a two-cycle trunk type engine is subjected to far more severe operation than in a four cycle crosshead engine. The two cycle engine is prone to run warmer, thereby to give rise to greater loss of oil through vaporization, particularly where the crankcase is a component part of the cylinders and exposed to the pistons.

Cylinder Lubrication

Cylinder lubrication in both the two and four-cycle engine can normally be accomplished by oils of similar characteristics, provided due consideration is given to low carbon residue content, and adequate viscosity to meet operating pressures and temperatures. Oil consumption in the two cycle engine will normally be higher than in a four cycle of the same cylinder size, in view of the location of the scavenging and exhaust ports, the somewhat higher temperatures, and the fact that a certain amount of oil will usually be scraped off from the piston and rings while passing these ports. Should the rate of oil feed be increased, in order to compensate for this potential loss, abnormal deposits might develop in the scavenging air and exhaust ports.

In the two-cycle Diesel, cylinder oil is subjected to high temperatures at more frequent

intervals over each cycle. By reason of the high velocity of the gases of combustion at the exhaust ports, the tendency towards vaporization of the lubricant is increased at this part of the cylinder. To reduce this effect an oil of lower volatility could be used, but the probable result would be an increase in carbonaceous residue formation around the piston rings.



Courtesy of McIntosh & Seymour Corporation

Fig. 3—Cutaway view of McIntosh & Seymour type of Diesel engine used for dredge auxiliary operations.

The four-cycle engine does not develop the same amount of heat during operation, nor is the lubricant on the cylinder walls subjected to the same high velocity and vaporizing action of the exhaust gases as in the two-cycle type. This is explained by the absence of exhaust ports, the gases being discharged in a straight line direction through the exhaust valves in the cylinder heads. While the normal difference in temperature between engines of the four-cycle and two-cycle types is not great enough to require special consideration in connection with cylinder lubrication, it must be remembered that under higher temperatures the oil consumption will tend to increase.

The relation of pressure to formation of an oil film is important in the four-cycle engine, as the pressure on the moving parts is not always of the same intensity. For this reason, it may be difficult for the lubricating oil to spread uniformly over cylinder liner surfaces when the piston rings are under pressure. In such engines, however, the pressure is relieved during the second stroke. This enables the oil to spread over the cylinder liners more readily and facilitates the sliding action of the pistons and rings.

Piston Rings Aid in Maintaining Oil Film

Piston rings in conjunction with a suitable sealing medium in the form of a lubricating film, serve to maintain a seal and prevent leakage of the high pressure gases past the pistons. Leakage, of course, would mean reduced efficiency. Although the metal surfaces of cylinders, pistons and rings are carefully finished and the rings are accurately fitted, leakage of gases cannot be prevented unless the clearances between the walls and rings are effectively sealed by the lubricant.

Metal surfaces in moving contact with each other will generate excessive heat and produce abrasion of the materials. This can be partly eliminated if the surfaces are separated and free motion permitted by means of a suitable fluid medium. Thereby metallic friction is replaced by less severe fluid friction, wear is reduced, and an adequate lubricating film is provided to aid the piston rings in sealing the piston. All this will result in greater unit power development per gallon of fuel consumed. The lubricating oil film must be maintained, however, under two distinct conditions of operation, i.e., high temperature and high pressure. The higher the temperature of the products of combustion, the hotter will be the adjacent parts, with consequent reduction in the body of the oil film separating the metal surfaces. The greater the gas pressure, the more difficult will it be to maintain a lubricating film between the rubbing surfaces, especially at the upper parts of the cylinders.

The gases will tend to escape past the split of each piston ring as well as past the clearance between each ring and its groove. This causes pressure to build up behind the rings. The highest pressure is, naturally, behind the uppermost ring, being nearly as great as that on the piston head itself; there is a gradual decrease in pressure behind each succeeding ring, however, until it becomes practically negligible behind the lowest ring at the bottom of the piston.

Cylinder Temperatures

Diesel engine cylinders are subjected to high temperatures because a large portion of the walls over which the pistons pass is swept by flame at every stroke in a two-cycle engine and every other stroke in a four-cycle engine. The initial temperature of this flame is at least 2000 degrees Fahr., ranging up to a maximum in the neighborhood of 2700 degrees Fahr., according to the type of the engine. Obviously, no lubricating oil film could stand

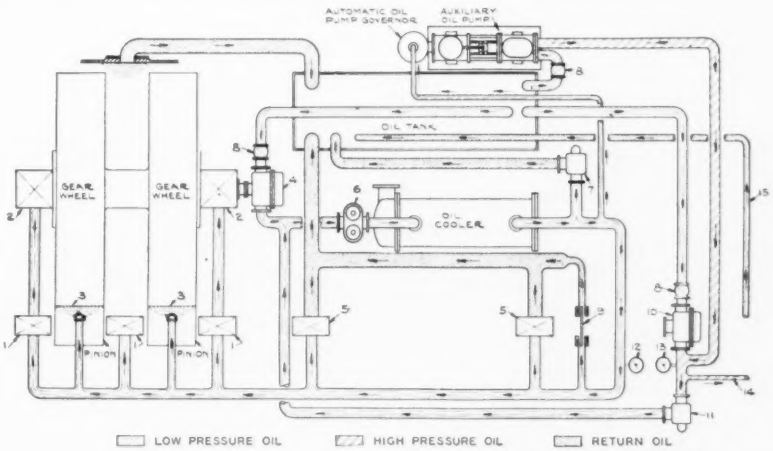
exposure to such temperatures, regardless of its refinement. Such temperatures prevail for only a short time, however, decreasing from the maximum as expansion and exhaust of the burning charge take place. There is then a gradual rise during the compression stroke. The minimum temperature is in the neighborhood of 250 degrees Fahr., while the average during a complete cycle is probably about 950 degrees Fahr. These temperatures pertain to the gases, however, and not to the cylinder walls.

As long as the circulating water is not boiling, it is safe to assume that the cylinder wall temperatures are not above 250 degrees Fahr., and the temperature of the pistons not many degrees higher. Therefore with proper cylinder and piston cooling, the high temperature of the gases should not cause any alarm. Furthermore, oils suitable for Diesel engine cylinder lubrication will normally have a flash point above 350 degrees Fahr. In other words, there is a factor of safety of at least 100 degrees. Lubricating oil does not burn readily and furthermore the time in the cylinder is short. An engine running at only 100 r.p.m. would expose the lubricated surface of the cylinder to the action of the flame for only a fraction of a second.

TURBINE, GENERATOR AND MOTOR BEARINGS

In the turbine or Diesel-electric dredge, sleeve type bearings require thoughtful study. This also applies to bearings of electric motors and centrifugal pumps. The general practice in the lubrication of turbine and generator bearings is to provide for force feed lubrication, using an oil of turbine grade which is capable of effectively resisting emulsification and permanent sludge formation. As a general rule the bearings of a turbo-generator installation are served by the same oiling system and very frequently means are provided in the form of a centrifuge or oil filter for continuous clarification of oil during circulation. Dependent upon the size of the installation, the oil may be handled by a pump located in the base of the turbine, which also serves as the oil reservoir, or if the installation is of considerable size, it may be advantageous to provide for external location of the oiling system, with adequate oil storage capacity to give the oil a certain amount of time to rest.

Sleeve type bearings on electric motors and centrifugal pumps, however, are normally lubricated individually. In the electric motor



Courtesy of Elliott Company

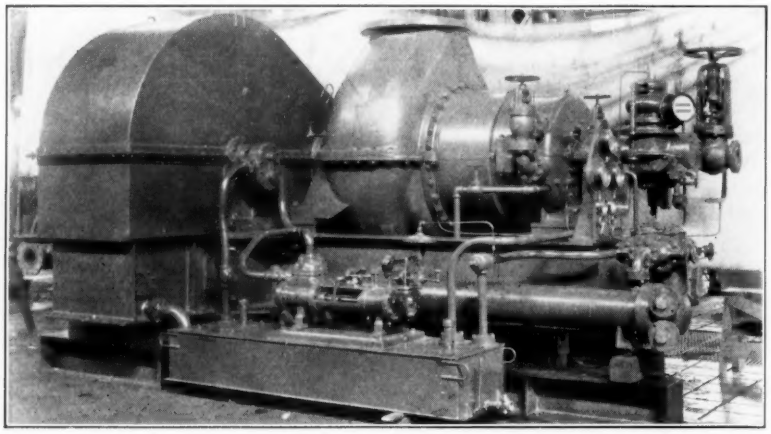
Fig. 4.—Oiling diagram for an Elliott steam turbine applicable to dredge operations. Flow of oil is clearly indicated by arrows. Pressure at various stages in the lubricating system can also be followed. 5—indicates turbine bearings; 3—the oil spray to gear teeth; 1—the pinion bearings, and 2—the gear bearings. 10—is the high pressure oil pump.

of the size applied to dredge service, ring oiled bearings have proved to be very effective. In this type of design the bearing is designed to carry one or more rings which are suspended from the shaft of the rotor. These rings revolve through an oil reservoir which is formed by the base of the bearing. Inasmuch as these rings hang free from the shaft and are of a somewhat larger diameter, as the shaft rotates, the rotation of the rings carries a certain amount of oil to the top of the shaft, from which it is directed into the clearance space between the shaft and the bearing through suitable oil grooves. At each end of the bearing there should be provision for return of the oil to the base reservoir, in order to eliminate the possibility of back pressure.

The ring oiled bearing, provided it is designed with an oil reservoir of adequate size, enables the oil to serve both as a lubricant and a coolant, just as it does in a pressure circulating system. Cooling in the ring oiled bearing is normally taken care of by radiation, whereas in the pressure system it may be advisable to install cooling coils. On the other hand, one must remember that the temperature of the oil as it is returned from the turbine bearing will normally be considerably higher than the oil returning from a ring oiled motor bearing.

Sleeve type bearings on centrifugal pumps, in turn, are generally provided for pressure grease lubrication. Because of the possibility of entry of water, it is generally advisable to use a water-insoluble type of grease, which is

compounded with an oil of sufficient viscosity to resist pressures developed during operation. This grease can be applied either by compression cups or by pressure gun through a suitable fitting. The pressure gun gives more assurance that the grease within the bearing will be kept free from contaminating or abrasive foreign matter, because there is less possibility of this gaining entry at the time re-lubrication is carried out. It also affords more pressure to drive out old grease from the bearing clearances and lubricating grooves, to assure free passage of fresh grease.



Courtesy of Elliott Company

Fig. 5—Showing typical view of geared turbine for dredge pump operation. External piping to and from pump and cooler is plainly shown.

The same principles of lubrication which pertain to bearings on centrifugal pumps will also apply to other grease lubricated plain bearings elsewhere on the dredge.

Oil Viscosity for Bearing Service

Determination of the proper viscosity of oil to use in steam turbine and electric generator service is of considerable importance, in the maintenance of reduced bearing temperatures. There are marked benefits to be derived from the use of low viscosity lubricating oils wherever constructional and operating conditions will permit. Steam turbine lubrication must very frequently be maintained for an indefinite period of time, over which the oil may be continuously re-circulated through the bearings and, in reduction gear machines, over the gear teeth, with only the protection which is afforded by partially by-passing a certain amount for continuous or periodic clarification. Circulation of oil in this manner through any bearing imposes a severe duty, especially where moisture or high temperatures may prevail. As a result, the original degree of refinement of an oil for turbine bearing service must be such as to make it highly resistant to oxidation, emulsification and sludge formation. Provided normal operating temperatures are not too high, as in the case where the steam inlet may be close to one of the bearings, the lower the viscosity of the oil, the more effectively will it perform its intended function. Bearing operating temperatures in turbine service will normally range from 130 to 180 degrees Fahr. Inasmuch as viscosity varies inversely with temperature, it is obvious that as temperature increases the body of the oil film may be proportionately reduced. It is perfectly practicable to maintain lubrication with a very light film of oil, especially where flood lubrication under pressure is brought about. Under such conditions the comparatively large volume of oil which is continuously being passed through the clearance spaces will in part make up for any possible failure of the oil film due to reduced viscosity. It is generally practicable, in a properly designed installation, to very accurately control oil temperatures by proper cooling. There should be no difficulty in dredge service in this regard, due to the accessibility of the water supply for this purpose. It is important to remember that the oil cooler should be periodically inspected for leaks, inasmuch as water may become a serious contaminant of the turbine oil and lead to emulsification and formation of permanent sludges especially under comparatively high temperature conditions.

Modern practice in steam turbo-generator design calls for the use of an oil ranging from 140 to 180 seconds Saybolt at 100 degrees Fahr. In reduction gear service where oil must serve both bearings and gears, the viscosity must be raised. As a general rule it should seldom be below 300 seconds Saybolt at 100 degrees Fahr., and very often in marine service it will be advisable to use an oil of approximately 500 seconds or even higher, under abnormal conditions.

For the sleeve type bearings of electric motors there is less chance of oil contamination as it may exist in the turbo-generator, temperatures are also not as high. As a result it will be practicable to maintain lubrication in a ring oiled system with an oil ranging from 180 to 300 seconds Saybolt viscosity at 100 degrees Fahr. Where advisable, the lower viscosity range will often aid in dissipation of heat from the body of the oil in the reservoir.

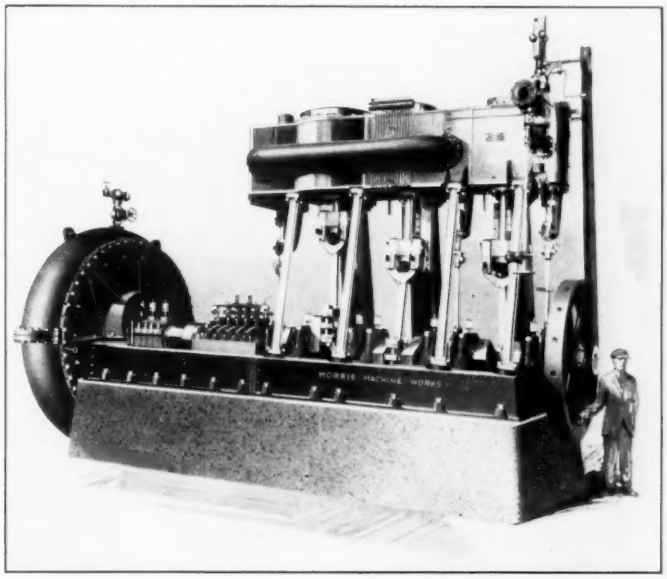
RECIPROCATING STEAM ENGINES

Lubrication of reciprocating steam engines and steam pumps can be broadly classified as external and internal. The former applies to all parts outside of the cylinders, including the eccentric mechanisms, the main bearings, the crosshead guides and the connecting rod bearings. Internal lubrication applies to the steam cylinders.

External Lubrication

The purpose of external lubrication is to reduce friction and wear to a minimum and to keep bearing temperatures within reasonable limits. It may be done by hand, oil cups, wick feed, gravity, forced feed, or a combination of these systems. The modern gravity wick feed systems, where the siphoning effect of strands of worsted yarn is utilized, can be classed as mechanical lubrication. The distributing centers are light metal boxes, from which the oil is taken by brass piping through sight feeds as directly as possible to the various bearings, each having its own independent pipe and set of connections. The number of such boxes depends on the size of the engine. Each is located at a point higher than any bearing to be lubricated and within reach of the grating, and fitted with a protective cover. The capacity is normally sufficient to give several hours of lubrication without refilling. Union joints are fitted where necessary, so that oil pipes may be quickly taken down and cleaned. The ends of the pipes in each oil box should extend above the normal oil level in the manifold to within about two inches of the top. The feed is regulated by worsted yarn wicks which give a regular and reliable supply of oil and act as automatic filters and strainers. They are frequently fitted with a lead sinker on one end and a twisted wire on the other. The sinker ends are submerged in the oil in the manifold, the wired ends being inserted in the feed pipes. Oil travels up the wicks by capillary action and siphons over, to subsequently drip into the pipes and be led to the various parts.

Lubrication is most dependable where the rate of oil feed is maintained practically constant and only in sufficient volume to lubricate the bearings adequately. Unfortunately, this cannot always be assured for when the oil reservoir is full the oil flows more freely, dropping off as the level falls. If at the low levels the bearings are receiving sufficient oil, then when the rate of flow increases with higher levels the conclusion must follow that an excess of oil is being used. In the great majority of cases wick feeds supply more oil than is necessary.



Courtesy of Morris Machine Works

Fig. 6—Showing a 20-inch Morris heavy duty dredging pump direct connected to a 16 inch x 27½ inch x 42 inch x 20 inch stroke triple expansion steam engine. Note thrust bearing between pump and engine.

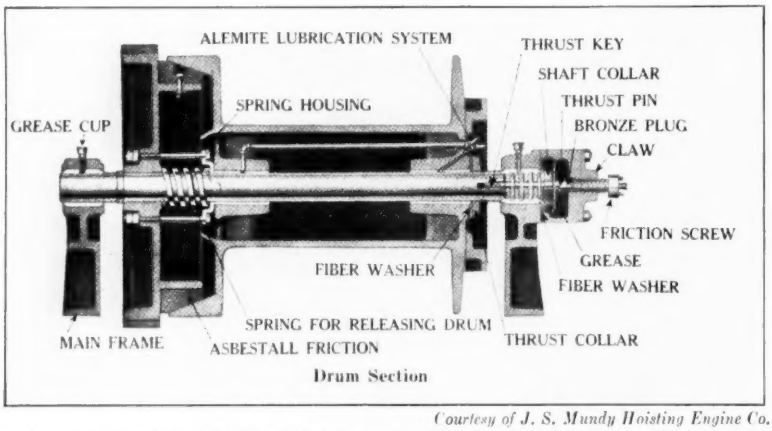
Compounding Improves Lubrication

For wick and hand feed lubrication marine engine oils should have a viscosity of about 750 seconds Saybolt at 100 degrees Fahr. They are usually compounded with blown rape-seed oil in varying percentages up to 20 per cent. The object in compounding mineral oils with blown rape-seed oil is to impart emulsifying qualities when in contact with water. In an emulsified state the viscosity of the oil is raised and its adhesive and cohesive qualities are greatly increased. In this condition the oil is able to resist successfully the washing effect of water which is always present around a marine engine.

Steam Cylinder Lubrication

In dredge service internal or cylinder lubrication of reciprocating engines is normally accomplished by means of pressure, using the hydrostatic lubricator or mechanical force feed oilers. It is also practicable to use hand oiling devices or sight feed cups, although such devices are generally less dependable than pressure operated units. Hand pumps, however, are sometimes advantageous in aiding lubrication when an engine is started cold, or when internal parts show tendency to groan or squeak. The hand pump must always be used

with careful judgment, as with this method more oil than is required may be pumped into the engine. The usual result is that the excess finds its way into the condenser with the exhaust steam.



Courtesy of J. S. Mundy Hoisting Engine Co.

Fig. 7—Sectional view of a Mundy hoisting engine drum. Note in particular the bearing design on the right with provision for grease lubrication and bearing protection.

Oil cups as a method of cylinder lubrication are obviously inefficient. The cup is filled, the cover replaced, the cock at the base is opened and the oil permitted to flow into the cylinder or steam chest. This system lacks regularity, results in waste of lubricant and demands frequent attention.

Hand swabbing of rods is quite practicable, however, and marine cylinder oils furnish good lubrication for the packing and stuffing boxes, provided the oil is applied at regular intervals.

Any oil for marine steam cylinder service must have great spreading ability to assure of maintenance of a lubricating and sealing film under the prevailing pressures and temperatures. It must also resist the washing effect of cylinder condensation, and be capable of furnishing maximum lubrication with minimum quantity, for this will reduce the possibility of carbon accumulations around the rings. Such an oil should separate quickly from condensed steam, in order to avoid boiler troubles.

The Hydrostatic Lubricator

This device is connected to the main steam line and depends for its action on the replacement of oil with condensate from the steam line. This type of lubricator must be started and stopped by hand. It is not absolutely regular or uniform in its delivery of oil, as changes in temperature, leakage, or any obstruction in the delivery passage may alter the rate of feed. For this reason, it must be kept under observation to insure good results.

The Mechanical Lubricator

Force feed lubrication is accomplished by the use of a mechanical lubricator, consisting of an oil reservoir and a suitable pumping unit for each oil feed. It is operated by a lever and ratchet motion which is attached to some moving part of the engine. Rate of oil delivery can be observed through sight feeds with which many such lubricators are equipped. There is also means of control provided to enable regulation of the oil feed. This method of cylinder lubrication is automatic and quite regular in its delivery of oil, thereby aiding in the development of oil economy, and positive cylinder lubrication. Temperature changes do not influence the feed of such a lubricator, and by its automatic operation supervision can be materially reduced.

Vertical Engines

Vertical cylinders are comparatively simple to lubricate as the weight of the piston, piston rod, cross-head and connecting rod are carried by the crank-pin. The only pressures on the cylinder walls are those due to the tension of the piston rings, and possibly to some slight pressure from any side motion which the piston may have.

The rings should always be accurately inserted, with just sufficient spring to prevent abnormal steam leakage. A film of oil thick enough to prevent excessive friction between these rings and the cylinder walls, and enough oil to maintain this film are all that is required to provide proper lubrication.

Where the condensed steam is used as make-up boiler feed and where adequate oil separation may be impracticable, it will frequently be advisable to run a vertical engine without any cylinder lubrication, on the assumption that the amount of water present in the steam will afford the necessary lubrication.

Horizontal Engines

Cylinder lubrication in a horizontal marine engine involves a somewhat more intensive problem than in a vertical engine. In the horizontal cylinder, except where tail rods are used, the weight of the piston, rings and part of the weight of the piston rod must be borne by the lower portion of the cylinder. On account of this weight, the piston will frequently tend to wear the bottom of the cylinder

out of round, and unless sufficient lubrication is provided the clearance between the piston and the cylinder may become so great as to cause serious blow-by of the steam past the rings. This increases the pressure to which the oil film is subjected and may weaken or entirely destroy it.

If the rings become worn and sharp on the edges, they will scrape the oil film off the surface of the cylinder walls, to increase further the friction and wear. Because of these conditions the cylinder oil must have characteristics which will provide a heavy film of oil, and it must be used in sufficient quantities to maintain this film. Even with the most efficient oil a certain amount of wear will take place. Rings should, therefore, be regularly inspected for wear and promptly renewed when necessary.

Tail Rod Supports an Advantage

Engines having heavy pistons and rods are, therefore, usually provided with tailrod supports, which, together with the crosshead, carry the weight of internal reciprocating parts. In such engines the only pressure on the cylinder walls is that carried by the tension of the piston rings. In consequence, lubrication can be maintained with less oil and without the need for such a heavy oil film.

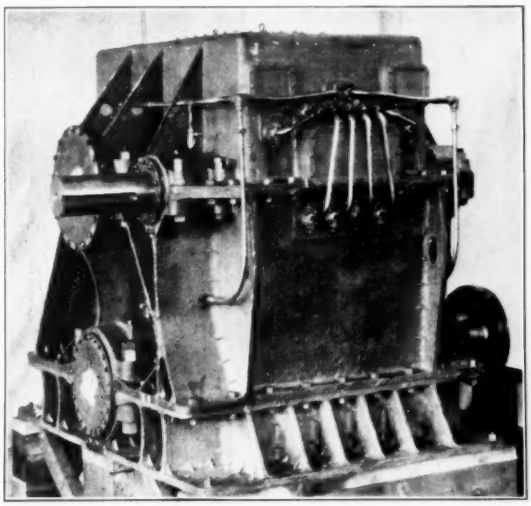
THRUST BEARINGS

In dredge service thrust bearings of the Kingsbury or horse-shoe collar type are chiefly used. The Kingsbury bearing and others designed along similar lines require the maintenance of wedge-shaped oil films. This is developed by having the segments or shoes which compose the stationary wearing surface so designed that under operating conditions they are very slightly inclined to the opposing or revolving wearing surface. The thin ends of the resultant wedge-shaped oil films point in the direction of rotation of the moving section of the bearing. The angle of wedge or the degree of tilt of the shoes varies according to the thrust pressure, the viscosity of the oil and the speed of rotation of the plain bearing thrust collar.

Lubrication Requirements

Thrust bearing lubrication is important inasmuch as overheating of the rings, collars or slippers due to lack of oil will rapidly cause scoring of the bearing surface, which often requires shut down for repairs. Wick feed, force feed or bath lubrication is generally employed. Of these, force feed is usually preferable, especially on the patented slipper type of bearing, for it more positively assures of maintenance of a uniform film of lubricant at all times. A straight mineral oil is generally regarded as best for such service, inasmuch as a compounded oil will have a tendency to emulsify in contact with water.

The thrust bearing housing should be kept



Courtesy of The Falk Corporation

Fig. 8—External view of a typical Falk gear set adaptable for operation of the cutter head in a hydraulic dredge. Wherever any reduction gear may be tilted on an angle, lubrication must be carefully studied. For this reason force feed lubrication of both gear teeth and bearings has been extensively adopted.

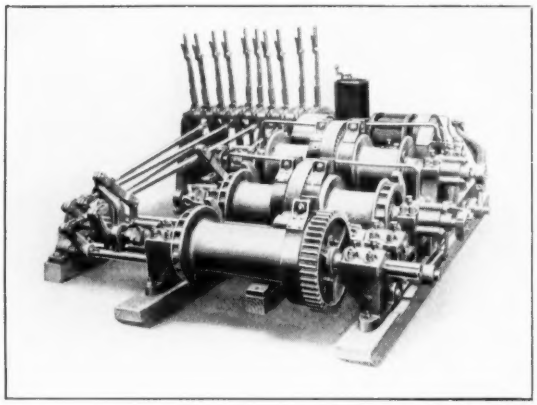
filled with clean oil to a level recommended by the builder. Leaks should be guarded against, inasmuch as accidental lowering of the oil level might result in overheating. Dirt, grit and other foreign matter are also serious factors in the lubricating system of such a thrust bearing, and may involve scoring, wearing of the bearing faces, and over-heating. As a general rule an oil for such service should be a straight mineral product, having a viscosity of from 180 to 750 seconds Saybolt at 100 degrees Fahr. Thrust oil properly chosen and applied will last for a considerable period if no objectionable features are allowed to interfere with the maintenance of the lubricating films.

Wick feed supplemented by bath lubrication is, in turn, generally found on horse-shoe collar and plain thrust bearings. Here the same oil as used on the main engine is suitable for this service. Considerable care must be exercised constantly in lubricating thrust bearings of these latter types, due to the usual practice of running with an emulsion of water and oil. During continued operation this emulsion will tend to become heavier and heavier until the oil ways will ultimately be so clogged that relatively the only lubrication possible will be furnished by the wick feeds. This may often lead to overheating. The engineer should, therefore, watch the nature of this emulsion carefully, and as soon as it

shows a tendency to thicken abnormally, the bearing should be thoroughly cleaned out and the oil renewed.

REDUCTION GEARS

Gears are essential to dredge operation in connection with the driving of certain of the



Courtesy of Morris Machine Works

Fig. 9—Showing a Morris five-drum electric driven dredge hoist. Relative location of all bearings is plainly indicated.

hoisting elements and for power transmission. There is a considerable problem involved in the lubrication of certain types of these gears, whenever they may be exposed or inadequately housed. This condition, of course, will make possible the contamination of the lubricant by abrasive materials, and if this continues the pitch line may be changed and noisy operation will result.

Pressure must also be considered. As a general rule tooth pressures will be comparatively high due to the small areas of contact. The more accurately the gears have been cut the more intense will be the pressures, inasmuch as line contact will more nearly prevail. This pressure will be constantly changing, as the gear teeth mesh with each other. Change of pressure will change the direction of application of the load. As long as rolling motion predominates, however, the effect on the structure of the teeth will not be serious, if they are properly lubricated.

In the event of wear, however, there will be a tendency for the motion between the teeth to become sliding instead of rolling. This will give rise to a certain amount of grinding between the teeth, which will accelerate wear, especially if the lubricant is incapable of maintaining a protective film.

A gear lubricant for dredge service must, therefore, possess sufficient oiliness to reduce friction to a minimum. This characteristic is dependent upon the viscosity and the ability of the lubricant to adhere to the teeth and resist the pressure which prevails. It is also essential to remember that the temperature involved should be considered. Under normal operation the majority of the gears required for hoisting will function at atmospheric temperature. As a result, the possibility of the gear lubricant being reduced in viscosity by abnormal heat is comparatively remote. Where speed reduction units are installed adjacent to the main engines, however, gear case temperatures may be higher than the temperature of the surrounding air. Normally the effects which low temperature may have upon a gear lubricant in service will require chief consideration. Certain grades of lubricants will have a tendency to congeal to such an extent as to become brittle and crack. If a lubricant has been properly refined, however, this possibility will be markedly reduced.

Straight mineral lubricants will generally be best adapted to dredge gear service. The average range in viscosity for use on exposed gears will vary from approximately 600 to 2000 seconds Saybolt at 210 degrees Fahr., although even higher viscosity maybe more nearly right to meet some requirements. Where gears are enclosed, however, as is the practice in connection with turbine or Diesel powered dredges, a more fluid lubricant will be advisable. The viscosity range in such installations will depend upon the means provided for handling the lubricant. Splash or bath lubricated gears of either the worm, spur or helical type may frequently require an oil of about the same viscosity as a heavy steam cylinder oil; that is, in the neighborhood of 150 to 180 seconds Saybolt at 210 degrees Fahr. Where oil is automatically circulated by means of a pump under considerable pressure, as is customary on more modern helical gear installations, the viscosity can be reduced to approximately 500 to 750 seconds Saybolt at 100 degrees Fahr.

LUBRICATION OF WIRE ROPE

The extensive use which is made of wire rope for hoisting purposes especially in the dipper and elevator types of dredges, and the exposed nature of the service presents a problem in lubrication which is too frequently overlooked.

It must be remembered that however efficiently the power plant may be operating, the ultimate degree to which the dredge hoisting machinery will perform its intended function will often depend upon the condition of the cables and wire ropes. It is obvious that should a rope have one or two broken strands, due to insufficient or improper lubrication, it might very easily lead to a tie-up of the machine should the ends of the strands interfere with the operation of the hoisting elements. This

might also involve a distinct hazard, for any wire rope in such condition is weak and more or less incapable of handling the loads to which it is subjected, especially in dipper service.

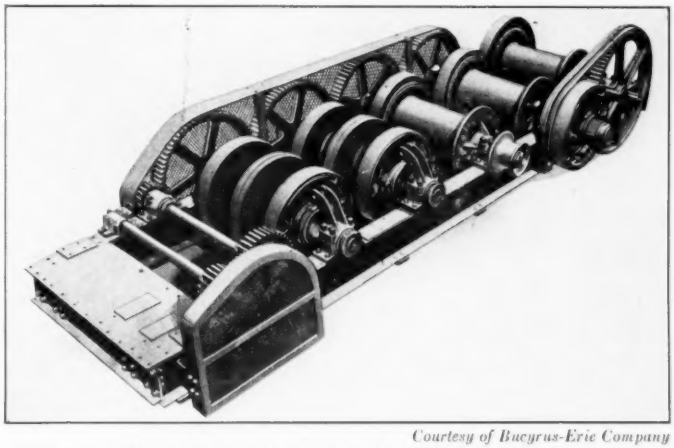
Wire ropes when new are lubricated by the manufacturer, being wound on an oil-saturated core. This, however, does not obviate the necessity for further lubrication. Under operation there is constant friction and wear between the strands and a tendency to squeeze out any contained lubricant, especially when the rope passes over sheaves or around drums. Renewal of lubrication should, therefore, not be neglected.

Friction, as it occurs between the strands of a wire rope, is essentially the same as friction between a bearing and a shaft. Overheating at the drums and abnormal wear will practically always result, to reduce the load-carrying capacity and increase the amount of power consumed in operation. Effective lubrication will aid in preventing this if it is brought about by proper application of a suitably prepared wire rope compound which will be capable of penetrating to the innermost strands and core of the rope, and is possessed of sufficient adhesiveness and body to resist being prematurely squeezed out or washed off by rain or sleet. On standby it will also prevent rusting and corrosion.

A wire rope lubricant should never cake, gum, or ball up, especially if contaminated with an excess of dust, dirt or metallic particles. Furthermore, it should resist the thinning-down effects of higher temperature. This, of course, directly involves the viscosity or relative fluidity of the product. In fact, viscosity in such a product is the essential characteristic involved in purchasing. It should not be assumed, however, as being the chief guide in regard to the actual suitability of a wire rope lubricant. In this regard the ability of the latter to function, penetrate and stick under actual operating conditions, is of outstanding importance.

The viscosity of a wire rope lubricant should range from 500 to 1000 seconds Saybolt at 210 degrees Fahr., according to the operating temperatures that may be involved, and the possibility of the presence of an excess of water. Where there may be possibility of such a product thinning down to the extent of dripping off, to perhaps result in lack of lubrication, increase in viscosity up to even 2000 seconds Saybolt or above may be advisable, even though it may involve perhaps a slight increase in drag. On the other hand, under relatively cold conditions, it might be advisable to use a thinner product, always, however, in accordance with the range of operating temperatures involved, and with the primary purpose of assuring protection of the rope.

Straight mineral petroleum products, devoid of fillers or thickening mediums are generally best for wire ropes, just as for gears. In other words, whatever the viscosity, it should be an inherent property of the lubricant, not an artificial characteristic which cannot be depended upon. Greases or soap thickened mineral oils are relatively unsuited to this class of service. To attain the requisite body a comparatively high percentage of soap would be necessary. Soap, of course, serves as the carrying medium for the oil. It has relatively no lubricating value, however, and affords but little protection against corrosion.



Courtesy of Bucyrus-Erie Company

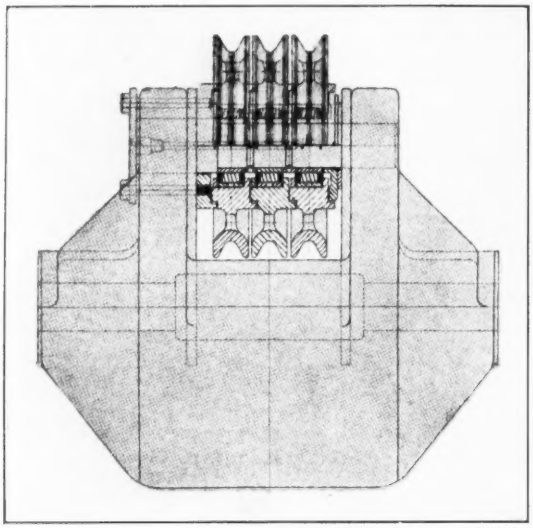
Fig. 10—Winch machine for a tin mining dredge. Exposed nature of gears on such types of installation calls for very careful lubrication.

Wire rope lubricants must frequently be applied relatively hot to reduce their viscosity and inertness, and to enable them to be more economically handled. Daubing or painting a rope with such a product at normal temperatures is often relatively ineffectual, for even though the surface might be more or less coated, there would be but little possibility of penetration within the strands. This latter is the secret of effective wire rope lubrication. As the rope is bent in passage over the hoisting drums, when it is properly lubricated the lubricant is aided in penetrating to the interior strands to prevent wear and corrosion.

AIR COMPRESSOR LUBRICATION

Compressor cylinders must be lubricated with an oil possessing certain very definite properties. It must not only lubricate effectively, but at the same time it must resist

decomposition when exposed to heated air. Otherwise, it might become a hazard due to the possibility of breakdown. Those properties which will indicate the ability of an oil to meet the above requirements are covered by the relative change in viscosity, the flash and fire



Courtesy of George Haiss Mfg. Co., Inc.

Fig. 11—View of constructional details of a "Hi-Power" bucket, showing location of Hyatt grease-sealed roller bearings. Lubrication of the sheave bearings in under-water service must be carefully studied.

temperatures, and the tendency to form carbon deposits.

The viscosity or relative fluidity of the oil will be subject to change with change in temperature. Due to the extent to which cylinder wall temperatures will vary, the viscosity of the oil used must, therefore, be given careful consideration, for the degree of piston seal attainable can be judged by the indicated viscosity of the oil at operating temperatures.

An air compressor oil, should, therefore, have a viscosity high enough to sustain the weight of the moving parts and form a proper seal between the piston rings and cylinder walls; it should never be so heavy, however, as to atomize with difficulty or develop excessive internal friction within itself. Moreover, if too heavy an oil is used the resultant film on the cylinder walls will more easily collect any dust that may be present in the air and bake on the hot surfaces to form carbon deposits. This is especially likely to happen when more oil has been used than just sufficient to lubricate the wearing surfaces, or where an air cleaner is not used.

High flash and fire points have been decidedly over-emphasized in their relative importance as qualifications for air compressor lubricants. In fact, observation of the conditions under which explosions occur has indicated that the possibility of formation of deposits within the compressor or air lines requires far more consideration. In any installation where they are present and rendered incandescent for any reason whatsoever, an explosion may occur irrespective of the flash or fire points of the lubricating oil. Otherwise, the oil would have to be submitted to a temperature much higher than its laboratory flash point before combustion could take place.

Petroleum oils are composite mixtures of hydrocarbons; therefore, different portions will be distilled or vaporized at different temperatures. Certain of the lighter products may pass off even at temperatures below the flash point, leaving the heavy ends dissolved in the oil next to the wall. The final result, especially where an excess of high carbon content oil is used, may be oxidation and the building up of a gummy mass which has a low vapor pressure and high distillation point. It is impossible to avoid this phenomenon, for mineral lubricating oils, regardless of their base or nature, will decompose to volatile products and carbon when subjected to hot air under pressure. On the other hand, the extent of this decomposition will depend on the length of time the oil is exposed to such heat. Naturally, it will also follow that with oils of the same degree of refinement the one which remains in the compressor cylinder or on the discharge valves the longest will form the greatest amount of carbon.

Obviously, an oil having a wide range of distillation, high end point, or too great a viscosity is objectionable, inasmuch as instead of vaporizing cleanly it breaks down as has been mentioned above, becomes sticky and collects dirt brought in by the air. The slower the breaking down process, or the greater the volume of oil involved, the more carbon will ultimately be developed, with greater possibility of subsequent trouble.

In view of the fact that pale, filtered, distilled oils, when properly refined, show the least tendency toward direct carbonization and the development of carbonaceous matter, they are generally accepted as best suited to air compressor service. Furthermore, any such direct carbon as may be formed through excessive use of such oils is normally of a light fluffy nature. Carbon deposits formed from improperly refined or unsuitable oils, on the other hand, are often of a hard, flinty nature. Any oil, however, will accumulate dust if the air is dirty and there is no provision for cleaning.

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DREDGE MACHINERY

TEXACO LUBRICATION RECOMMENDATIONS

Steam Reciprocating Engines	
Steam Cylinders	TEXACO LEADER CYLINDER OIL, OR TEXACO MARINE CYLINDER OIL
Bearings	TEXACO MARINE ENGINE OIL A, OR TEXACO DOLPHIN MARINE ENGINE OIL
Steam Turbines	
Direct Connected Units	TEXACO MARINE DYNAMO OIL, OR TEXACO REGAL OIL B
Gear Reduction Units	TEXACO MARINE TURBINE OILS, OR TEXACO ALCAID OR ALGOL OILS
Diesel Engines	
Cylinders	TEXACO ALGOL OR URSA OILS
Crankcase	TEXACO ALGOL OR URSA OIL
Air Compressor	TEXACO ALCAID C, ALGOL C, OR URSA OIL C
Electric Generators	
Bearing Oil Circulating Systems	TEXACO ALCAID OIL, OR SAME OIL AS USED IN TURBINE SYSTEM
Thrust Bearings	
Kingsbury Type	SAME OIL AS USED IN MAIN ENGINE, OR TURBINE
Horseshoe Collar Type	
Oil Lubricated	TEXACO MARINE ENGINE OIL A, OR TEXACO DOLPHIN MARINE ENGINE OIL
Grease Lubricated	TEXACO STAR H GREASE NO. 1
Gears (Spur or Bevel)	
Exposed	TEXACO CRATER COMPOUND NO. 1 OR NO. 2
Enclosed	TEXACO CRATER COMPOUND B OR NO. 00
Worm Reduction Units	TEXACO LEADER CYLINDER OIL, OR TEXACO THUBANS
Wire Rope	TEXACO CRATER COMPOUNDS ACCORDING TO OPERATING CONDITIONS
Bearings (Pumps, Blowers, Electric Motors, Gear Sets and Machine Tools)	
Oil Lubricated	TEXACO MARINE DYNAMO OIL, OR TEXACO MARINE TURBINE OIL M
Grease Lubricated	
On Deck	TEXACO STAR H GREASE NO. 1
In Engine Room	TEXACO CUP GREASE NO. 3
Flexible Couplings	
Gear Type	TEXACO MARFAK NO. 2 OR NO. 3
Spring Type	TEXACO CUP GREASE NO. 1 OR NO. 3
Auxiliary Air Compressors	TEXACO CETUS OIL OR ALCAID OIL
Steam Pumps	
Cylinders	TEXACO LEADER CYLINDER OIL, OR TEXACO MARINE CYLINDER OIL
Bearings	TEXACO MARINE ENGINE OIL A, OR TEXACO DOLPHIN MARINE ENGINE OIL

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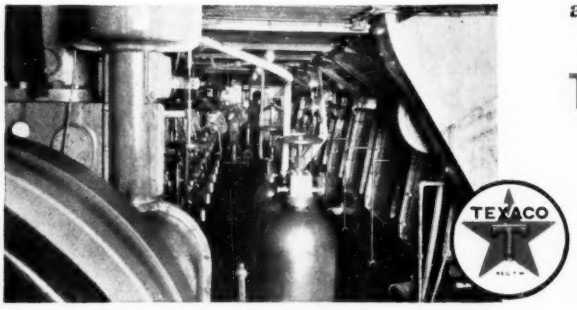

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